The 3rd MinnHoKee Lecture Abstract

HoKeeMinn Lecture 2008

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Lecture 1 (Department Colloquium): May 22 (Thursday)
Composite materials: An old field of study full of new surprises

Abstract: Composite materials have been studied for centuries, and have attracted the interest of reknown scientists such as Poisson, Faraday, Maxwell, Rayleigh, and Einstein. Their properties are usually not just a linear average of the properties of the constituent materials and can sometimes be strikingly different. The beautiful red glass one sees in old church windows is a suspension of small gold particles in glass. Sound waves travel slower in bubbly water than in either water or air. In the last few decades composites have been found to have some surprising properties. Most materials, such as rubber, get thinner when they are stretched, but it is possible to design composites which get fatter as they are stretched. Electromagnetic signals can travel faster in a composite than in the constituent phases. It is possible to combine materials which expand when heated to obtain a material which contracts when heated. Similarly it is possible to combine materials with positive Hall coefficients to get a composite with negative Hall coefficient. It is still an open question as to what properties can be achieved when one mixes two or more materials with known properties. This lecture will survey some of the progress which has been made.

Lecture 2. May 23 (Friday) 10:30-12:00
Variational Principles for Acoustics, Elastodynamics and Electromagnetism

Abstract: The Dirichlet and Thompson energy minimization variational principles for electrical conductivity are well known, as are the analogous variational principles for elasticity. Less well, known is the result of Cherkaev and Gibiansky that these variational principles can be extended to allow for complex conductivity tensors, and complex elasticity tensors, corresponding to the quasistatic limit where the wavelength is much larger than the body. Here we show that these variational principles can be extended to the full equations of acoustics, elastodynamics and electromagnetism at any fixed frequency, not just in the quasistatic limit. This is joint work with Guy Bouchitte and Pierre Seppecher.

Lecture 3. May 23 (Friday) 4:00–5:30
Superlenses and Cloaking

Abstract: The making of an object invisible through some cloaking device until recently was commonly regarded as science fiction. Two quite different types of electromagnetic cloaking were proposed in early 2006. In our cloaking scenario a ollection of finitely many polarizable dipoles becomes essentially invisible when they are within a certain critical distance of a superlens. Superlenses have attracted attention because they promise resolution on a length scale finer than can be achieved using conventional lenses, i.e., finer than the wavelength. The radiation scattered by the polarizable dipoles resonates with the superlens and acts back on the dipoles to essentially cancel the field incident on them, which is why they become invisible. Dipolar energy sources supplying constant power also become invisible.

A second type of cloaking was proposed by Pendry, Schurig and Smith and Leonhardt. In this scenario a shield cloaks objects to incident electromagnetic waves by guiding the waves around the object. This work is related to the earlier work of Greenleaf, Lassas and Uhlmann, on cloaking for conductivity. Here we will review these developments and also discuss how cloaking might be extended to elasticity using these ideas. This requires new materials, in particular materials with anisotropic mass density and a Willis-type constitutive law in which the stress depends on the velocity and the momentum depends on the displacement gradient. We sketch how such materials, with behavior outside that of continuum elastodynamics, might be made. This is joint work with Lindsay Botten, Mark Briane, Ross McPhedran, Nicolae Nicorovici, and John Willis.